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Poulsen, Peter Behrensdorff; Dam-Hansen, Carsten; Flarup Jensen, Katrine; Bentzen, Barbara; Katic, Ivan; Poulsen, Søren

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DTU Fotonik
Department of Photonics Engineering

Technical University of Denmark

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Peter Poulsen & Carsten Dam-Hansen,
DTU Fotonik, Department of Photonics Engineering
Frederiksborgvej 399, 4000 Roskilde
K. F. Jensen & B. Bentzen, Faktor 3, Copenhagen, Denmark
I. Katic & S. Poulsen, Danish Technological Institue, Taastrup, Denmark

Introduction

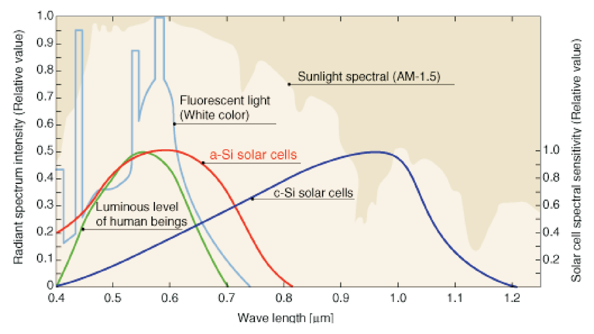
The aim of the project is to investigate the potential of exploiting the advantages of solar cells in not-optimal light conditions in the urban environment from <1000 W/m2 in best cases of light. It addresses the gray scale from BIPV to minor applications driven by solar cells and thereby cutting the grid-connection saving CO2, energy and manpower in the mounting phase. Cable-laying inevitably involves digging up and repaving public roads, and thus also underground work which in average cost 400 DKK pr. meter and up to 10 times more in the city center and the energy used goes to waste CO2.

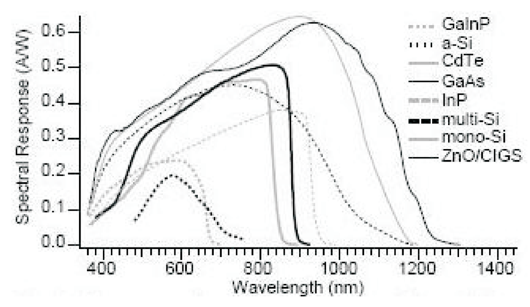
If this potential for savings should be exploited the following task needs to be addressed:

- Measuring and deriving irradiance data in not-optimal conditions in the urban environment spectrally as well as by intensity
- Measuring a variety of solar cells (different manufacturers and technologies) to have data material for matching suited solar cells to given conditions.
- Examine potential PV CO2-neutral substitutes for existing applications in the city and a look into the market potential, drivers and obstacles.
- Developing a software tool to predict size and PV technology for a given application.

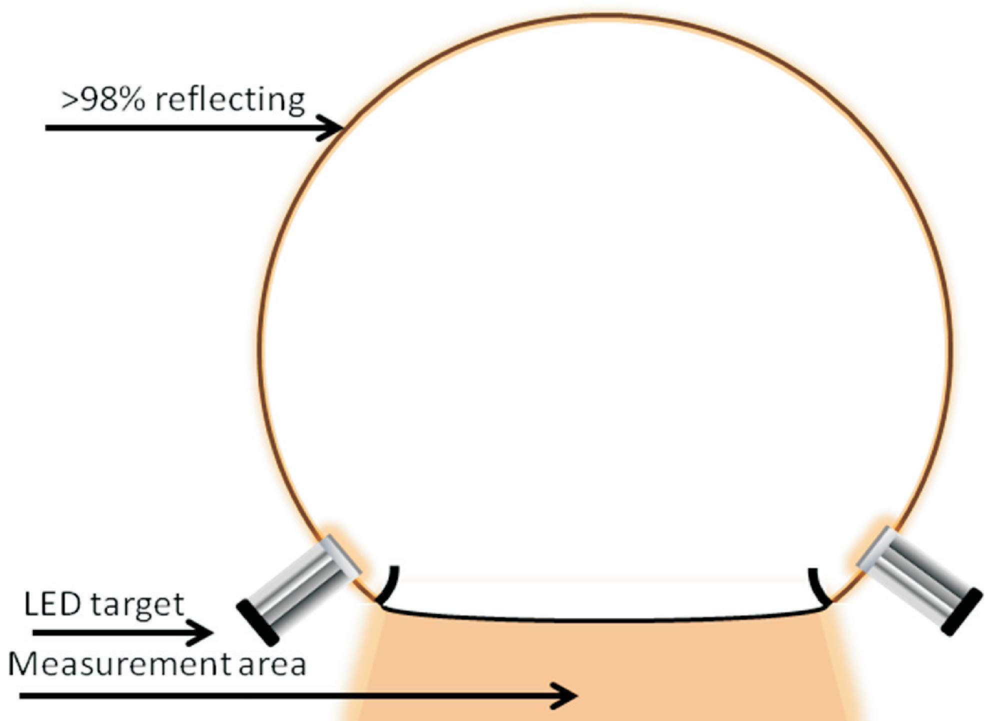
LED Sun

The deeper the solar cells are put into the urban environments between buildings the larger the part of the energy amount reaching it will come from diffuse lighting. As can be seen from the curves to the right the spectral response of different solar cell technology are very different. Also under low light conditions the individual solar cells from the same company begin performing very differently. To obtain knowledge the different solar cell types and be able to match and select them for a given application a LED Sun simulator is build. It is based 2 LED arrays in each 100 nm interval from 400 nm to 1000 nm. They can be controlled via a Labveiw program together with a Kiethley 2400 source meter to make electrical characterization of the cells and hereby obtain full knowledge of the spectral response curve of the solar cells/panels at different intensities in the area of 1-200 W/m2. The measuring spot is 30x30 cm. The system is finished by the end of 2009.





Measurement	400-500 nm	500-600 nm	...	800-900 nm	900-100 nm
x W/m²					
2 x W/m²					
... x W/m²					



The system is based on an integrating sphere where all the light from the LED targets are reflected several times and the distribution of the light is there for very good on the measuring spot. One of the major obstacles has been creating the mechanical system where >98% lambertian scattering is required over the adressed spectrum from 400 nm to 1000 nm. Commercial paint from Labsphere based on Barium Sulphate can do the job but the cost is close to 4.000 € pr. square meter. This might not be a problem in the optical laboratory industry where there a few players on the marked and the laboratories happily pays a high price for having the best quality equipment for their measurements but in this project where several systems need to be build to find the best suited this cost is killing. A home made BaSO4 based solution has therefore been developed and cost's about 50€ for painting the whole system.

Software tool and conlussions

The software tool will be web based and will make it possible for designers of PV systems to the urban environments to chose the right size and technology of solar panel for their specific application. The software is not fully developed since light data and PV data are still lacking.

The project is done together with Faktor 3 and Danish Technological Institute.

The project was financially supported by the Danish Energy Association through FORSKEL under project no. 2008-1-0113, Towards a CO2 neutral urban environment – Cutting the wire.

PVPark LED lamps

Outdoor lighting is another obvious application of LED technology. A new park lamp of high quality both technically and by modern design, based on LED technology is being developed in a collaboration between DTU Fotonik, DONG Energy, Mads Odgaard Design, Ark-Unica and Albertslund Kommune.

The definite aim of the project is to develop a prototype of the LED lamp, for the purpose of lighting paths, squares and open spaces, and to test the lamp in Albertslund kommune. The photo (right) shows the first setup of five new LED lamps at Kanalgaden in Albertslund Centrum.

The photo also shows 12 stones set in the pavement with provides pathway LED illumination. These are solar cell powered and provides a CO2 neutral illumination.
The solar LED stone is developed in a collaboration between DTU Fotonik, Outsider, DONG Energy and Faktor 3.

Design sketch by Mads Odgaard

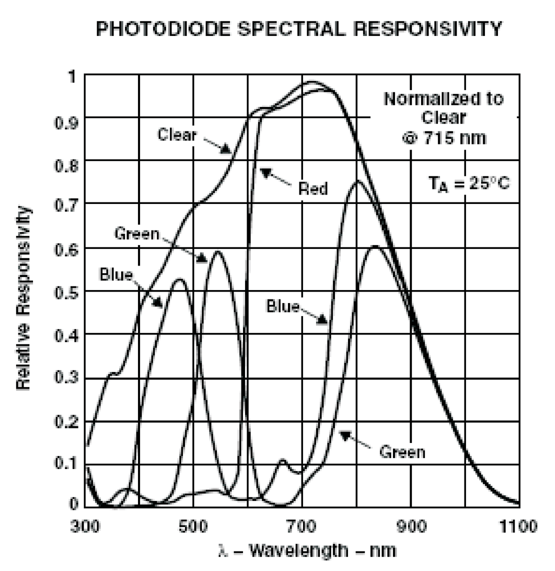
LED test installation at Kanalgaden in Albertslund.

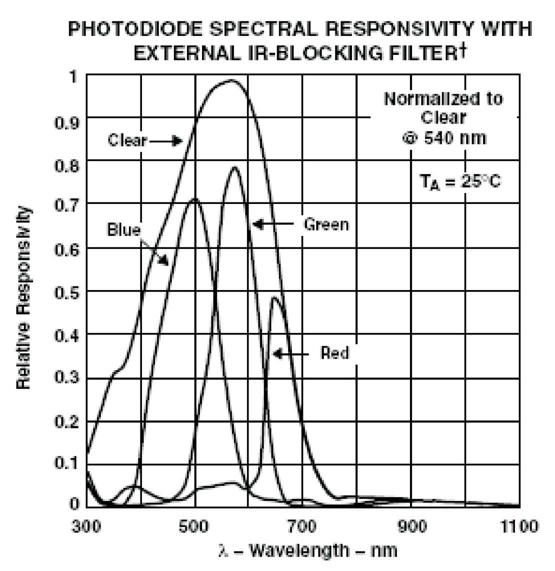
A new project is planned to be launched next year where the knowledge of this project and the LEDSun should be used to choose solar cells for the PV version of the Albertslund Park lamp and several other PV applications for the urban environement including optimization of the Sun Stone to the left.

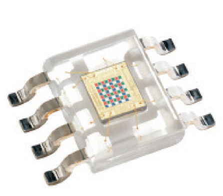
Light sensor

To make a mathematical model and be able to choose solar cells from it for a given application and placement in the urban environment the spectral distribution as well as the total irradiance needs to be measured over at least half a year. The optimal equipment for such measurements are a spectroradiometer, but since more than 40 measuring spots needs to be addressed for at least half a year such unit is too costly and needs to be plugged in. It was therefore necessary to develop a logging unit for the measuring purpose with a target price of 100€ pr. unit. Below the spectral response of the unit can be seen. By different filtering it can be seen that rough information of the light distribution in 100 nm intervals can be obtained.

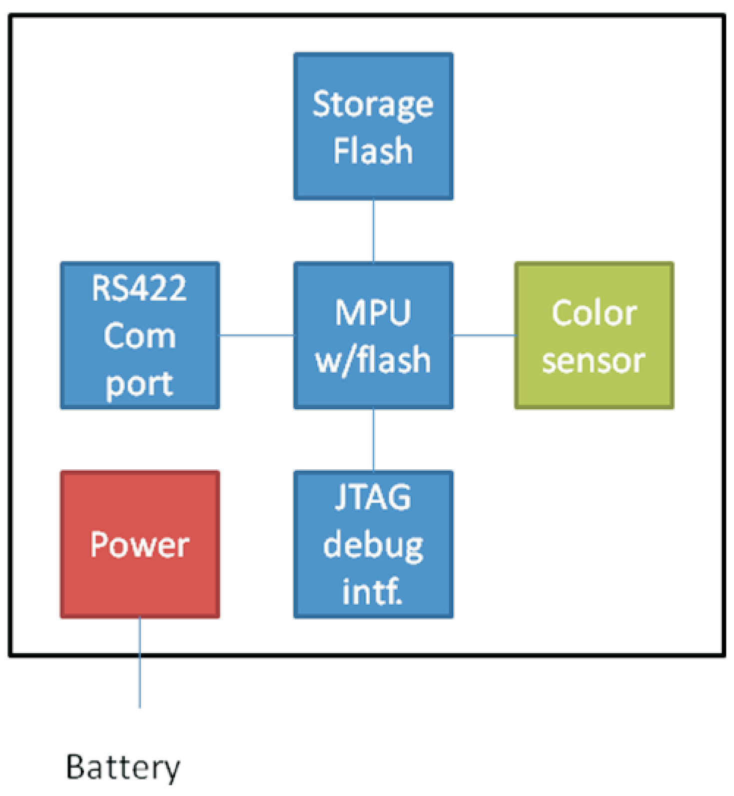
The units is under production and will be placed in relevant spots before the 21st of December 2009. Hereafter measurement every 3 minutes will be made and the data correlated with weather data and roof-top total irradiance measurements.

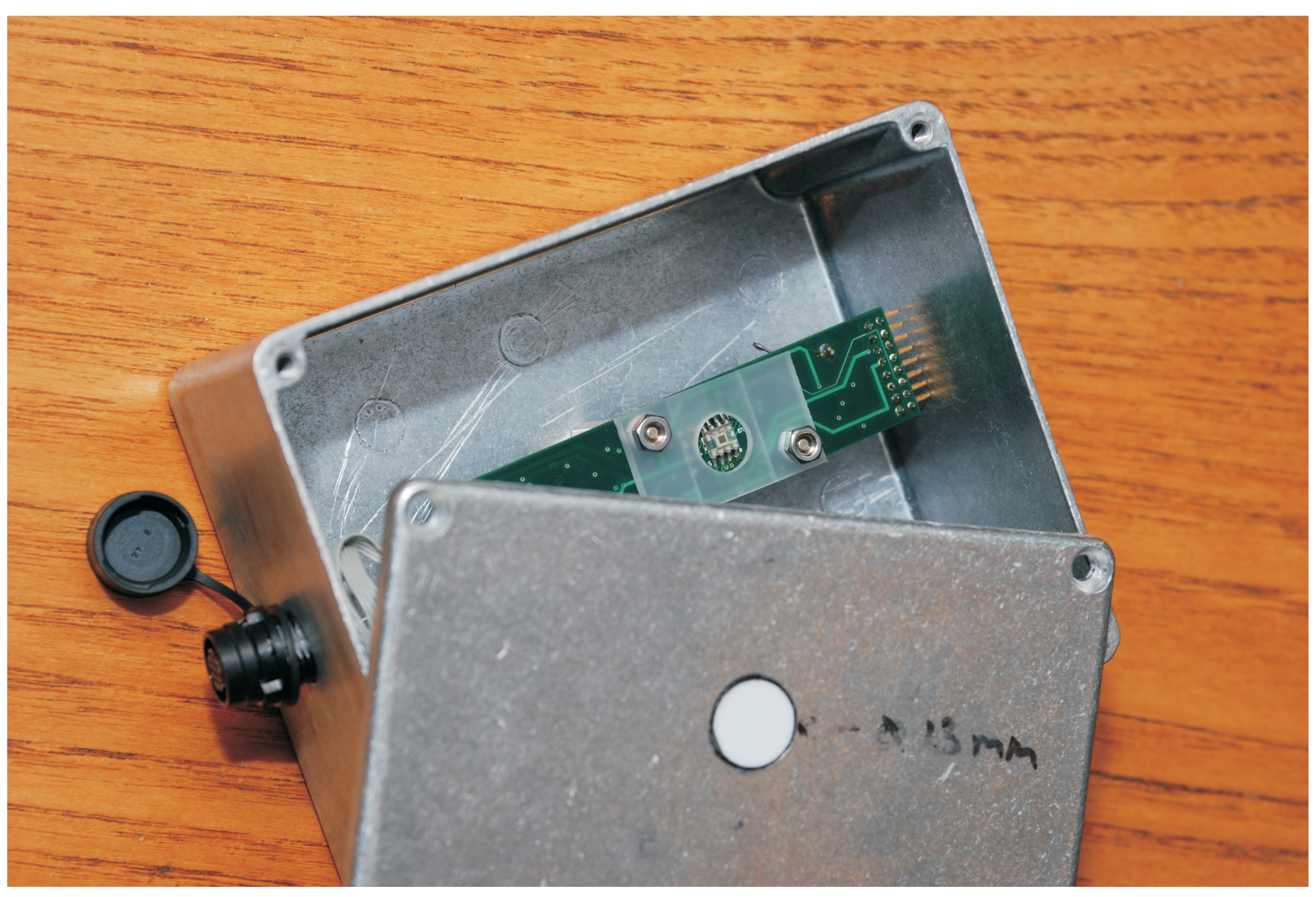






To the left the TAOS TCS230 color sensor is chosen for the the setup. Below is a block diagram of how the PCB is made. The unit is powered by a Li-ion battery and uses 1 mA at all times and a little more when measuring. It is a target to lower the standby usage of the unit. The resolution of the measurements is 16 bits and it is stored in the Flash memory.





Here the 1 version of the light measuring unit is shown. It is based on a color sensor sensitive in the spectrum 400nm -1100 nm and by different filtering and by calibration it can be made to work as a rough spectrometer with a solution of 100 nm in the adresses area. For correction purpose the sensor is also measuring the total energy received by it. The unit is made watertight, IP67.